ALTERNATIVAS PARA LA PROMOCIÓN DE LA EFICIENCIA EN LOS PUERTOS. UN MARCO TEÓRICO[1]

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Abstract

During the last decades, the European Union (EU) has devoted a large amount of effort and money to projects aimed at encouraging some of its maritime corridors as a modal alternative to road or rail freight transport. However, in many cases the overall design of most of these programs has ex post revealed as very ineffective. This paper suggests that promoting port efficiency might be a more suitable target to increase the modal split of Short Sea Shipping (SSS) than subsidizing firms to transfer cargo from road to sea. But defining 'port efficiency' is a complex task by itself, and, therefore, granting money directly to port authorities could also generate perverse moral hazard effects, particularly when many investments when the improvements are difficult to monitor and many investments are non-refundable. The European Court of Auditors (ECA, 2012) points out that millions of EU public port finance was wasted on empty terminal and other unused infrastructure. The objective of this paper is to design a second-best mechanism; a proper subsidy to promote SSS by encouraging port improvements through a proper system of incentives. As a policy recommendation, here we propose the development of a *subsidy per inefficiency-reduction unit*. We think that only if port operators perceive the benefits of decreasing loading-unloading, administrative and port access times, then this policy will meet its real objective.

Keywords: Maritime transport policy; incentives; ports; moral hazard; subsidies.

JEL Codes: L91, L98; R42.

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[1] Although the usual disclaimers remain, we acknowledge valuable suggestions from Javier Campos, Juan Luís Jiménez and Jorge Valido.

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1. Introduction

Transport is a market that is far from having arrived at a stage of even fair competition, especially between modes (COM, 2009a). Since the early 90s, the EU has developed different projects to promote maritime corridors as an alternative to road traffic, highlighting their potential in the freight market (COM, 2007).

As many authors state, (COM, 2011; Medda and Trujillo, 2009; Paixao and Marlow, 2002) Short Sea Shipping (SSS) is an environmentally friendly mode of transport; it reduces external costs in comparison to road or, even rail. Thus, the EU has encouraged its role.

Particularly, the EU developed the Motorways of the Sea Program (MoS), consisting of regular SSS corridors between two European ports with a specific frequency—as air transport does with airports. By this, SSS turns into highways on the sea using proper port terminals and vessels (Baird, 2007).

To attain this goal, the EU has spent above 895€ millions but the results in terms of modal split show no significant impact. In the last decade, road market share has improved while sea transport has decreased; the difference between both has increased from 4.6% to 9.8% (Suárez-Alemán et al, 2012).

Costs associated to port infrastructure represent a large proportion of the cost structure of maritime transport (Limao and Venables, 2001; Clark et al, 2001; Sánchez et al, 2003; Wilmsmeier et al, 2006). However, the role of ports, as nodes, has been under-estimated.

Promoting port efficiency—by increasing the speed of cargo loading/unloading, the fast access to ports, the administrative procedures, and customs, among others—may be more effective to increase the modal split of SSS than just giving grants to companies[4]. For instance, let consider that a company that chooses a maritime route instead of a road route receives some public funds to operate in a specific corridor. If port access are not well designed (in terms of infrastructure and logistics) and operating times increase highly, companies could be unwilling to suffer long waiting times, thus they would still prefer road transport. The EU policy would have no effect. Therefore, port efficiency in terms of times would turn into a vital issue in a mode that usually suffers from longer total times.

The port industry comprises a relevant number of agents: port authorities, consignees, terminal operators, shippers, and local authorities, among many others. They all compose the well-known logistic chain, whose total time is the sum of individual times. As expected, each agent may generate delays, bottlenecks, and other failures on port activity—for example, congestion in port access, a slow procedure from

[4] To transfer cargo from road to sea is the main requirement that Marco Polo I and II programs establish at the time to give grants which not have to be refund later.

authorities, queuing at storage site or a low hourly cargo load/unload rate. This makes tough to reach an agreement in the definition of the port efficiency.

This paper points out port efficiency and its influence on maritime corridors competitiveness, instead of evaluating SSS in Europe, nor determining when and where these corridors are the best transport alternative.

To give grants to port authorities to reduce their inefficiency could generate some perverse effects: some ports could receive aids that they would not have to refund later nor showing the achieved positive results, thus we would face a moral hazard problem. The EU cannot easily observe the real effort that ports exert to reduce inefficiency; a non–positive result could be explained by the lack of effort or other exogenous circumstances. Even when the UE observes a bad performance, its monitoring process becomes extremely bureaucratic and dawdling. Therefore, procedures to deal with those issues stumble down a blind alley[5].

Indeed, the European Court of Auditors (ECA, 2012) states that millions of European Union public port finance was squandered on ineffective transport projects. That means empty ports and unused infrastructure. The report finds 16 out of 27 audited transport projects—which covered 85.5% of allocated the EU cohesion and structural funds between 2000 and 2006—ended up unsuccessfully.

In this paper we design contracts to incentive ports to reduce inefficiency through the EU transport programmes. The latter objective is to encourage reductions in total times throughout the logistic chain by removing the above-mentioned bottlenecks. The structure is as follows: after considering the state-of-the-art, we discuss the current EU policy in maritime sector, and the role played by ports. In Section 3, subsidies in maritime transport policies are modeled. Then, the relation between the government and port infrastructure is examined under the framework of a moral hazard problem. From this, Section 5 reflects how to incentive a port inefficiency reduction. Lastly, conclusions and policy recommendations are presented.

2. European Maritime transport: the role of port infrastructure.

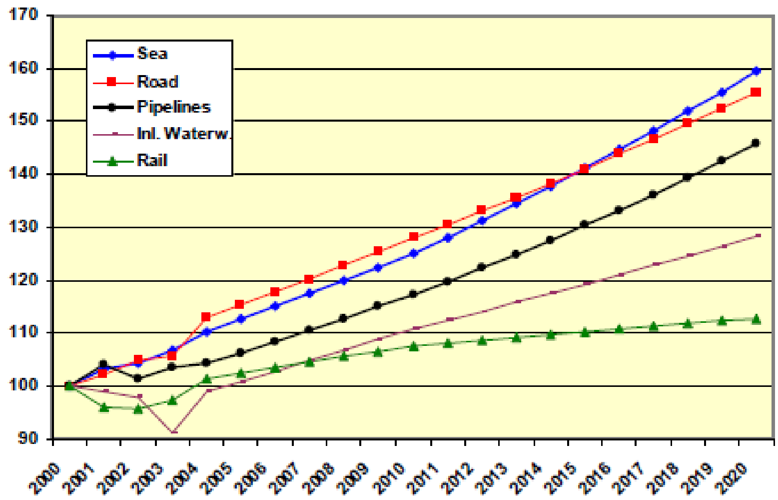
As COM (2006) states, *with two-thirds of its boundaries facing the sea, the European peninsula is a maritime economy par excellence, especially after enlargement. Waterborne transport, especially short sea shipping has over the years grown as strongly as road freight transport and clearly has an even stronger potential. It can help to alleviate congestion and environmental pressure on other modes, provided pollutant*

[5] In three cases audited, the European Court of Auditors (ECA) found that the allocation of over €30m of EU cohesion and structural funds has led to three empty ports, two in Spain (Campamento and Arinaga) and one in Italy (Augusta). In these cases, the EU has not asked for the refunding of the grants, but to redefine the use of them. By now, the ECA recommendation has been to *remind Member States of their obligation to use EU funding in a way compatible with the tenets of sound financial management. To do so, the Commission should provide appropriate guidance and disseminate best practices found in Member States* (ECA, 2012).

emissions from shipping are reduced. Therefore, the European Commission (EC) recognizes the advantages that maritime transport provides.

The EU has developed a set of actions to encourage maritime transport during the last decades. The Pilot Action for Combined Transport (PACT), Marco Polo I and II, and (especially) Trans-European Transport Network (TEN-T)[6] have been designed to promote maritime transport and to reach a balanced modal split in freight transport. These are mainly focused on the establishment of SSS routes as an alternative to road transport and, specially, on the MoS project.[7]

Figure 1. Expected growth in freight transport activity by mode (2000=100)



Source: COM(2006)

As figure 1 presents, maritime transport will turn into the leader of freight transport market. This mode is predicted to grow to 5.3 billion tons in 2018—more than 1.5 billion tons from now—(COM, 2009). Thus, the EC recognizes that the EU's ports infrastructure will need to manage this growing demand. For this, *increased investment within ports and towards the hinterland is necessary in order to improve and extend services so that ports become poles for growth instead of potential transshipment bottlenecks* (COM, 2006). Therefore, a successful ports policy will need to clarify rules for public contributions to investment.

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[6] These programmes can be classified in two groups: those dedicated to fund the transport infrastructure (TEN-T) and those dedicated to support operations and activities (PACT and Marco Polo I and II). The former has been running since 1996 to encourage European cohesion by improving long-distance communications and providing the basic infrastructure for the movement of goods, services and information in the EU. The PACT, Marco Polo I and II have been developed to transfer the total growth of international road freight transport to alternative modes as rail or sea transport, not only to combined options.

[7] This program establishes "floating infrastructures" to improve access to markets throughout Europe, by developing fixed corridors which meet specific frequency among other requirements. By now, EU has designated four corridors: Motorway of the Baltic Sea, Western Europe, South-East Europe and South-West Europe. COM (2004).

Baird (2007) states that traditionally the EU has expected the private sector to finance maritime transport investments, while the public sector has not had any doubt in investing as much as rail or road need—or even more. In other words, road and rail infrastructures receive more public funds than maritime ones yet (Gese-Aperte and Baird, 2012).

Likewise, some authors point out the role of port infrastructure as a determinant of the maritime cost structure. Limao and Venables (2001) account a poor infrastructure for more than 40% of predicted transport cost. Pettersen (2004) agrees that port charges generate the 40-60% of overall transit costs. Clark et al (2004) also point out that "bad" ports have the same impact on transport costs as being located 60% farther away from markets. Previous studies highlight the importance of ports in maritime transport competitiveness. Adequate cost-effective and efficient ports are essential to reach a modal shift in freight transport (Paixao Casaca, 2008).

Gese-Aperte and Baird (2012) also identify ports as key factors for the development of MoS, reflecting that some port services must improve their adequacy for SSS. A proper development of SSS requires high port efficiency (COM, 2004). The Commission points out the bottlenecks arising from administration, documentation and custom procedures as the main source of inefficiency.

Empirically, Baird (2007) highlights port efficiency as an essential service attribute together with prices, reliability, schedule, transit time and on-board facilities through a survey of shippers carried out during the European Marine motorways project (EMMA). They consider as essential not only the speed of loading/unloading or low port charges, but also other aspects such as cargo security, absence of bureaucracy, 24-hour working and fast access to the road network; that is, they all related to the degree of efficiency of ports.

Paixao Casaca (2008) comprises the requirements considered by port authorities to properly develop SSS. According to operational criterion, these authorities demand a high coordination between port and transport operations and reduced ships' time in port *to a minimum*. Regarding to information handling, the author also suggests a speedy transfer of documents between intra-ports and inter-ports actors, and also software to simplify customs operations, among others.

Maritime transport has been traditionally under-considered—especially in terms of financing. Moreover, within European maritime policy, ports have been even less promoted: in 2001, public investment in ports represented between 5 and 10% of total Community investments in the transport infrastructure (COM, 2001). Nevertheless, COM (2009a) currently states that *the challenge is to provide the right mix of measures to ensure that ports can cope efficiently with their gateway function.* Section 3 develops a theoretical model to meet this Commission's purpose.

3. Modeling subsidies in maritime transport policies

The existing economic literature points out maritime transport as a more competitive mode when external costs are considered. Thus, the EU has developed policies to attain a most sustainable freight transport. Programmes such as Marco Polo I and II have given grants to companies that shift cargo from road to sea transport, mainly. These grants have not to be refund. Therefore, they have the same effect on modal shift as reducing costs; the impact on market shares of carriage price changes are conditioned by time spent on shipping activity (Suárez-Alemán et al., 2012).

Moreover, shipping times do not only comprise journey time, but also access and waiting times, loading and unloading times and each administrative procedure which may delay the movement of freight. These times are highly correlated with the efficiency degree of the infrastructure.

Let consider, for instance, the need of adapting terminals to SSS requirements by accomplishing multimodality (through getting road or rail links closer to the terminals) or by improving hinterland-ports connections. Maksimavicius (2004) points out as SSS requirements the increase of terminal gateways, custom and border points or the size of storage facilities. All previous measures could diminish total times of cargo in ports. Therefore, we name *port inefficiency* (η) as a bad performance of this infrastructure, expressed in terms of times. Obviously, an efficient performance would be identified through the comparison among ports or terminals, there is no an objective value of a good or bad implementation in terms of time[8]. Thus, in here the port or terminal inefficiency has to be regarded as relative to others.

We notice that part of this inefficiency could not be directly handled through physical infrastructure improvements. Here we refer to those caused from bureaucratic procedures. We could also consider the managerial or operational systems as port infrastructure (for example, the Information Technological Services, ITS), and they could be addressed to reduce administrative times as well.[9]

Our study departs from the suggestion that port infrastructure should be promoted to increase maritime transport modal shift, by reducing port inefficiency. However, as García-Alonso and Martín-Bofarrul (2007) point out, the volume of investment to increase efficiency is no guarantee of success. In our paper we assert that

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[8] The existing literature has traditionally dealt with port inefficiency in terms of quantities or movements in ports. There are numerous studies that analyse and compare it among ports or terminals by using techniques such as Data Envelopment Analysis (DEA) or Stochastic Frontier Analysis (SFA), mainly. Cullinane (2010) provides a very detailed review of methods and applications on productivity and efficiency of these infrastructures. Basically, these studies result in efficiency rankings by establishing relationships between inputs (p.eg. labour force, physical facilities, cranes, berths, etc.) and outputs (p.eg. TEUs, movements, etc.).

[9] COM (2009b) reflected these types of measures, with the objectives to simplify customs formalities for vessels only sailing between EU ports; to establish guidelines for speeding up documentary checks or to rationalize the documents requested under different bodies of legislations. The establishment of an E-maritime Policy or E-Freight look for the goal to improve ITS systems across European ports.

a proper contract has to be designed to reach the objective proposed, and that is essentially the basis of the following section.

3.1. The model

There are several agents in our model setting. The government (representing the overall society), whose objective is to minimize the total generalized cost, road infrastructure (R) and port infrastructure (P)[10]. From a social perspective, each agent must be taken into account. So we have to minimize the aggregate social cost defined as the sum of the aggregate generalized cost of each transport mode plus the subsidy that the government gives to port infrastructure operator.

The generalized cost per mode is the sum of the monetary component (*m*)—the access fees to the infrastructure, the consumption of fuel and other required components to travel from origin to destination—and the non-monetary component. That is, the invested time and the value of the invested time plus the externality cost of each mode ($\varepsilon^R > \varepsilon^P$). The invested time is decomposed into a minimum invested time and the port infrastructure inefficiency (η). Technological characteristics limit the minimum invested time while infrastructure inefficiency (η) depends on the exerted effort by the infrastructure operator. For instance, there is a minimum time required at the time to access to a terminal (i.e., transit time, basic procedures). There is also a second source of time spent when getting into a port if we consider the congestion at the access—due to long waiting times in customs, an insufficient number of access, etc—that could diminish through the proper investments. Our analysis considers that there is only inefficiency in the maritime transport associated to the port infrastructure[11].

$$\mathrm{CG}^P = \mathrm{m}^p + \mathrm{v}\left(\mathrm{t}^p + \eta(e)\right) + \varepsilon^p \tag{1}$$

$$\mathrm{CG}^R = \mathrm{m}^R + \mathrm{vt}^R + \varepsilon^R \tag{2}$$

First, we consider that the monetary component of both modes, $m^P = m^R$ are equal to focus mainly on the role of the infrastructure inefficiency (η). Second, there is heterogeneity in the valuation of the invested time (*v*); the willingness to pay for time differs at individual level. It is distributed as an uniform between [0,1]. This potential heterogeneity is useful to determine the proportion of consumers that are more prone to move using port or roads.

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[10] It has to be noted that this analysis could be done by considering terminal operators instead of port authorities. Therefore, the model here presented could be implemented in different port structures.

[11] Our analysis is robust if we consider any degree of inefficiency associated to the road infrastructure. In that case, η can be reinterpreted as the relative inefficiency of the port infrastructure with respect to the road one.

By comparing both generalized cost, R and P, there is an indifferent shipper between both modes. That is, $CG_i^P = CG_i^R$ characterizes the critical value of the invested time v_i^*. This threshold determines the market share of each mode. It is pretty straightforward to reach the following solution where

$$v^* = \frac{-\varepsilon^P + \varepsilon^R}{t^P - t^R + \eta(e)} \quad (3)$$

*v** is a critical value that determines the demand per mode. Given that individuals distribute as an uniform between [0,1], those with a time valuation in the range [0,v*] choose maritime and those with a time valuation higher *v** choose road transport. In other words, port infrastructure operator has a demand equal to *v**, while road has a demand equal to (1-*v**). Both depend on the infrastructure inefficiency (η) and indirectly on the exerted effort. Thus, the profit function of the port infrastructure is

$$\pi = (m-c)\left(\frac{-\varepsilon^P + \varepsilon^R}{t^P - t^R + \eta(e)}\right) - k - c(e) + S(\eta(e)) \quad , \quad (4)$$

where *c* represents the cost per unit, *k* the infrastructure capital cost, *c(e)* is the cost of the effort exerted by the operator and *S(η(e))* is the subsidy that depends on the inefficiency and indirectly on the effort exerted. To simplify the previous effort cost function, we assume that $c(e) = e$ and $e \in \{0,1\}$. This implies the existence of different degrees of effort from the lowest to the highest. Thus, we face the following normalization $c(0) = 0$ and $c(1) = 1$.

4. Government and Port infrastructure: A moral hazard problem.

Given previous expressions, the government cannot observe the effort exerted by the infrastructure operator; it faces a moral hazard problem[12]. There exists the risk that port infrastructure receives a subsidy for not exerting any (or a low) degree of effort. Therefore, the objective is to obtain a second-best solution, that is, a proper subsidy to promote maritime transport.

This implies that the information is not symmetric. As Compes and Poole (1998) state, regulator and private logistics firms face to a principal-agent relationship. Noticeably, the operator who has an informational advantage will try to use it to his benefit.

[12] For further analysis of moral hazard, see Laffont and Martimort (2002).

Here the assumption is that operator's behaviour is not observable by the government or, in case of being, it is not verifiable. That is, the effort cannot be included in contract terms. Even though the operator's behaviour is not verifiable, we assume we will know it at the end of the period. Consequently, the obtained result will be included in the contract that stipulates the operator's pay-off.

As Barros (2003) states for the Portuguese case, the government is under-informed in relation to the return of its policies, so ports are free to establish their own private goals, bypassing the public objectives that they are assumed to pursue. Considering the United States ports, Luberoff and Walder (2000) suggest that subsidized balance-sheet financing means that port authorities tend to underestimate the risks involved with investments, so they could not choose the optimal investment in each case. It could be sentenced that port authorities could have some political incentives far from just a social economic perspective.

Concretely, the problem is as follows; the government proposes a menu of contracts depending on the effort exerted by the port infrastructure. The higher the effort, the more likely is to get a higher inefficiency reduction. But, the government has to minimize the social cost (S.C.), satisfying two conditions; the participation constraint (P. C.) and the restriction of incentives compatibility (R.I.C.).

The P.C., in our setting, implies that profits of the port infrastructure must be above zero, that is, to have positive profits[13]. It has to be noted that this function includes the subsidy, so this constraint is not determining if ports are profitable or not without public funds. The R.I.C. indicates that a port infrastructure exerting a low effort cannot receive a subsidy that corresponds to a higher type. In other words, exerting a higher effort leads to a higher subsidy.

Taking into consideration a probabilistic approach and assuming that effort is a continuous variable, the problem is as follows.

$$Min\ SC$$

$$\sum_{i=1}^{N} p(e)[(m-c)\left[\frac{\varepsilon^R-\varepsilon^P}{t^P-t^R+\eta(e)}\right]-k-e+S\left[\eta(e)\right]\geq 0 \qquad (5)$$

$$\frac{\partial}{\partial e}\left[\sum_{i=1}^{N} p(e)[(m-c)\left[\frac{\varepsilon^R-\varepsilon^P}{t^P-t^R+\eta(e)}\right]-k-e+S\left[\eta(e)\right]\right]\geq 0 .$$

This problem is solved as usual for inequalities, that is, with a Kuhn-Tucker approach (see Annex I).

[13] The participation constraint implies that the objective function of the port operator is to maximize his private profits. This assumption has consequences on the management model but not directly on the ownership. Maximizing private profits as a management goal can be attained by public or private operators.

$$L(e,\eta,\lambda,\mu) = SC + \lambda\left[\sum_{i=1}^{N} p(e)[(m-c)\left[\frac{\varepsilon^{R}-\varepsilon^{P}}{t^{P}-t^{R}+\eta(e)}\right]-k-e+S[\eta(e)]\right]$$
$$+\mu\left[\frac{\partial}{\partial e}\left[\sum_{i=1}^{N} p(e)[(m-c)\left[\frac{\varepsilon^{R}-\varepsilon^{P}}{t^{P}-t^{R}+\eta(e)}\right]-k-e+S[\eta(e)]\right]\geq 0\right], \quad (6)$$

Solving that problem for e, we have the equilibrium condition.

$$1 = -\lambda - \mu\left(\frac{p'(e)}{p(e)} + \eta''(e) + \eta'(e)\frac{S''(\eta)}{S'(\eta)} - \frac{(c-m)(\varepsilon^{P}-\varepsilon^{R})\eta''(e)}{S'(\eta)(t^{P}-t^{R}+\eta(e))^{2}}\right). \quad (7)$$

Corollary 1. *The ratio* $\frac{p'(e)}{p(e)}$ *is positive with respect to e what means that the higher is the effort exerted; the more likely is to reduce the inefficiency.*

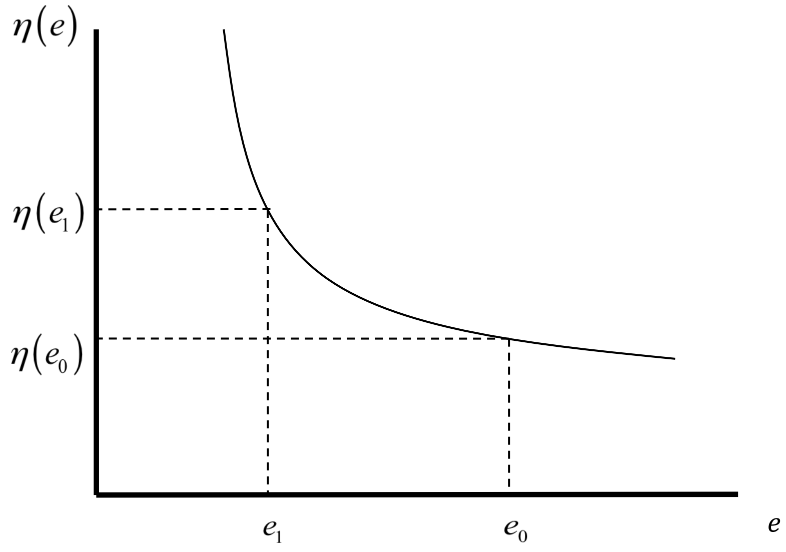
This ratio introduces rationality in the analysis;[14] without this traditional result, there would not be any initial incentive to exert any degree of effort. Previous expression may be simplified if we assume a linear relation of the subsidy with respect to the inefficiency, then $S''(\eta) = 0$. This assumption seems reasonable if we consider that the government would subsidy to ports for each "unit of inefficiency" reduction (for instance, waiting hours in ports). Thus, the expression is

$$1 = -\lambda - \mu\left(\frac{p'(e)}{p(e)} + \eta''(e)\left(1 + \frac{(m-c)(\varepsilon^{P}-\varepsilon^{R})}{S'(\eta)(t^{P}-t^{R}+\eta(e))^{2}}\right)\right). \quad (8)$$

$\eta''(e) < 0$ assumes a concave function of the inefficiency with respect to the effort. That is, the marginal contribution of the effort is lower and lower in terms of the inefficiency reduction.

[14] Innes (1990) characterizes optimal contracts in a model with a risk-neutral principal and a risk-neutral agent, both with limited liability constraints, using the first order approach described below for concave utility functions (see also Park 1995). Milgrom (1981) proposes an extensive discussion of the Monotone Likelihood-Ratio Property (MLRP) assumption.

Figure 2. Port inefficiency and effort exerted relationship.



Therefore, there is a trade-off between the effort exerted by the port and the reduction of its inefficiency. There is a cost associated to exert the effort c(e)—equal to *e* in our assumption. Each port (or terminal) would choose its own combination of (η*, e*).

The concave function is reasonable when considering that most inefficiency reductions could be handled with investments on technological improvements or optimization systems of bureaucratic procedures.[15]

Rearranging previous expression in terms of the likelihood ratio and renaming $\Delta\varepsilon = \left(\varepsilon^P - \varepsilon^R\right)$, $\Delta b = \left(m - c\right)$ and $\Delta t = \left(t^P - t^R\right)$; the expression is

$$\frac{p'(e)}{p(e)} = \frac{-1-\lambda}{\mu} + \eta''(e)\left(1 + \frac{\Delta b\,\Delta\varepsilon}{S'(\eta)(\Delta t + \eta(e))^2}\right) \tag{9}$$

Knowing that the left-hand side of the equation is positive, we get some reasonable findings on our parameters. Regarding external costs, maritime transport has

[15] We assume that reduction inefficiency can be attained by continuous technological improvements or optimization systems. But, port operators usually face discontinuity and improvements are associated to step functions. Qualitatively, our model would not change; we should only substitute derivates by discrete changes.

been pointed out as a more environmentally friendly mode than road (Medda and Trujillo, 2010; Paixao and Marlow, 2002). Thus, $\Delta\varepsilon < 0$. Lastly, we also assume that ports cover its operational costs.

Corollary 2. *Under the previous assumptions* $\eta''(e) < 0$, $\Delta\varepsilon < 0$ *and* $m > c$, *a necessary condition is* $S'(\eta)(\Delta t + \eta(e))^2 < -\Delta b\,\Delta\varepsilon$.

Both terms are positive; the right hand side of the previous condition is fixed considering that prices and externalities are not affected by the subsidy. The left hand side depends crucially on two unknown functions $S'(\eta) = 0$ and $\eta(e)$. Here we can discuss among different types of contracts—depending on different subsidies schemes— to determine how they incentive port inefficiency reductions. Next section analyses previous conditions by bearing in mind three different specifications.

5. How to incentive gains in port efficiency

The final inefficiency reduction crucially depends on the specific contract policy that the government chooses. Concretely, in here we assess three different possibilities.

First, the government could consider a fixed payment subsidy that the operator would receive regardless of the exerted effort. Second, a payment proportional to the inefficiency reduction is also considered and third, the government could choose a two-part contract with a fixed payment plus a payment proportional to the inefficiency reduction. In order to get tractable expressions, we assume that the relation between effort and inefficiency is characterized by $\eta(e) = -e^2$ that is, a concave function.

Fixed payment

It represents the most frequent mechanism exerted by the governments for funding ports. This scheme comprises each policy based on giving a fixed amount of money to port authorities or terminal operators.

In this setting, the infrastructure operator's behaviour chooses the smallest possible effort. Then, the government will anticipate this reaction, so if he proposes a contract based on a fixed payment, he chooses the wage that exactly compensates the operator for his effort.

Proposition 1. *Under a fixed payment, the effort exerted by the operator is equal to 0,* $e = 0$. *Therefore, the optimal contract is a fixed payment equal to 0,* $S(\eta) = 0$.

Fixed payments—as grants—are popular in the EU. Indeed, the TEN-T programme comprises the concession of a fixed subsidy to port improvements, where the EU covers a percentage of total project costs. The TEN-T programme finances around 268 ongoing and 59 closed projects with a budget of more than €7 billion.[16] Its aim is to encourage the cohesion and interconnection of European countries, by investing in each transport mode. Approximately 1% of the total amount is designated to port improvements[17]. Their actions (as other programmes such as Marco Polo I and II) subsidize projects with a specific amount of money no related to any result. Thus, ports have no incentives to make a proper use of the funding; they could not be exerting the required effort.

Proportional payment

The operator receives a payment proportional to the inefficiency reduction. Let assume that the proposed contract takes the form $S(\eta)=\alpha\eta$.

The operator maximizes his profits considering this contract and the government takes the operator's decision as given to choose the minimum α.

Proposition 2. *The minimum* α *, the one that determines the government's choice, is given by* $\alpha^{MIN}=\frac{\Delta b\,\Delta\varepsilon}{\left(e^2-\Delta t\right)^2}-\frac{1}{2e}$.

The marginal payment per inefficiency reduction depends negatively on the exerted effort. Thus, the level of effort has a double role under this scheme. On one hand, the higher the effort is, the higher the inefficiency reduction is; on the other hand, the higher the exerted effort is, the lower the marginal payment per inefficiency reduction is.

Here it is necessary to analyse the role of alpha in previous expression. It is straightforward to observe how this parameter establishes a direct relationship between the degree of inefficiency and the subsidy. In other words, α represents the value of the inefficiency.

Port inefficiency, as we stated, is a question of time: access and waiting times, loading and unloading times and each administrative procedure—customs and sanitation, among others—may delay the movement of freight from origin to destination.

Turning this model into an effective policy, a proportional payment would require the establishment of a *subsidy per inefficiency-reduction unit*. Linking the

[16] March 2012. http://tentea.ec.europa.eu/en/ten-t_projects/

[17] http://tentea.ec.europa.eu/en/ten-t_projects/statistics/projects_managed.htm

subsidy with an inefficiency-reduction—by giving funds for removing unnecessary administrative procedures, improving the access to the terminal or implementing ITS systems, among others—would be the key to make effective the current EU maritime transport policy. This would have to meet the alpha-minimum condition determined above. Thereby, port authorities or terminal operators would internalize the indirect benefits of each exerted effort. The final subsidy would not depend on the effort but on the achievements in port efficiency. From this, the entities would be encouraged to do their bests.

Two-part contract

Let consider the establishment of a two-part contract. That is, a fixed payment and a proportional one. In our case, it means $S(\eta) = \delta + \alpha\eta$.

This mixed contract is always theoretically preferred to the other alternatives. In fact, both previous results can be obtained with this contract scheme; a more flexible contract allows us to attain a lower social cost.

Proposition 3. *Fixed part of the two-part tariff does not give incentives to the operator to exert any level of effort. Thus, the optimal two-part tariff becomes a proportional one with* $\delta = 0$*, and* $\alpha^{MIN} = \frac{\Delta b \, \Delta\varepsilon}{\left(e^2 - \Delta t\right)^2} - \frac{1}{2e}$.

The fixed parameter does not induce any effort: a two-part contract would turn into a proportional payment, since fixed fee would not offer any incentive to reduce the inefficiency in port or terminal activities.

Hence, by comparing the three proposed contracts, the proportional payment becomes the best alternative when considering the inefficiency reduction as the main goal. Lastly, we should characterize the final equilibrium. That is uneasy if we do not consider more restricted assumption or if we solve the problem for a particular case. However, we have just concluded that a proportional payment equivalent to the inefficiency reduction is the best alternative. This result validates our thesis that subsidies similar to those proposed by European Commission are not an efficient mechanism for forcing port or terminal operators to exert an effort in the inefficiency reduction.

6. Conclusions and policy recommendations

It is broadly agreed that port efficiency is a major issue in maritime competitiveness. As in every company or institution, the proper performance of its activities is crucial to determine its success. The EU recognizes the advantages of maritime transport for the

European society. Maritime corridors are accepted as the most environmentally friendly transport mode, and also as an adequate competitor to road.

Traditionally the EU has expected the private sector to afford investments in maritime transport, not being the case of other modes such as road or rail (Baird, 2007). Thereby, promoting maritime corridors has become a strongly requirement to reach the maritime advantages, especially in terms of environment and competition.

The need of improving port efficiency is also pointed out by the EC through its different reports during the last decades. Mainly, it is regarded as a way to promote maritime transport and, at the same time, to support these improvements. However, this does not mean that the EU should support these projects without any condition. In this paper we assert that the European programmes should link the funding with the effort exerted by port operators. Current subsidies are a virtual waste of money when they deal with port efficiency, not considering that sometimes ports could not have the same incentives than governments.

We suggest that the government—mainly the EU, but also the national or regional authorities—cannot observe the effort exerted by the infrastructure operator; it faces a moral hazard problem. That means there is a risk when port infrastructure receives a subsidy even if they do not exert any (or a low) degree of effort. In other words, the information of the government and infrastructure operators to a contract is not symmetric. Thus, in here we design a proper contract that gives incentives to port authorities to exert the highest effort.

As mentioned, port inefficiency is mainly a matter of time: the more the movement of cargo in port/terminal takes, the more inefficient the port/terminal is. The European freight market is characterized by the intermodal competition. When a shipper faces the choice of a mode or another, total times are crucial in its decision. Thus, longer times in ports reduce drastically the maritime transport competitiveness. In other words, the reductions of times in ports should be regarded as efficiency gains.

In this model we prove how a proportional payment that connects the port efficiency achievements with the subsidy is the best mechanism to incentive ports to do their bests. As a policy recommendation, here we propose the development of a *subsidy per inefficiency-reduction unit*. If port operators perceive the benefits of decreasing total times—by reducing administrative procedures or improving access to the infrastructure, among others—, then the policy will meet its real objective. Thereby, the efficiency gain process would be internalized.

Lastly, we remark the necessity of developing a proper database of times in ports. National port authorities should be worried about this matter if their objective is to take the most of their funds. Without a right knowledge of time in port processes and procedures, there is no chance of detecting the weakness and, therefore, of enhancing the advantages of maritime transport.

7. References

Baird, A. (2007). The economics of Motorways of the Sea. Journal of Maritime Policy & Management, 34(4), 287-310.

Barros, C.P. (2003) Incentive regulation and efficiency of Portuguese Port Authorities. Maritime Economics & Logistics, 5, pp. 55-69.

COM (2001) Communication from the Commission to the Council and to the European Parliament of 13 February 2001: Reinforcing Quality Services in Sea Ports: a Key for European Transport [COM(2001) 35 - Not published in the Official Journal].

COM (2004) Decision No 884/2004/EC of the European Parliament and of the Council of 29 April 2004 on amending Decision No 1692/96/EC on Community guidelines for the development of the trans-European transport network. Official Journal of the European Union L 167.

COM (2006) Communication from the Commission to the Council and to the European Parliament Keep Europe moving - Sustainable mobility for our continent - Mid-term review of the European Commission's 2001 Transport White Paper.

COM(2007) Communication from the Commission. The EU's freight transport agenda: Boosting the efficiency, integration and sustainability of freight transport in Europe.

COM (2009a) Communication from the commission to the europan parliament, the council, the European Economic and Social Committee and the Committee of the Regions. Strategic goals and recommendations for the EU's maritime transport policy until 2018.

COM (2009b) Communication and action plan with a view to establishing a European maritime transport space without barries. European Commission, 11.

COM (2011) White Paper. Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system. European Commission.

Cullinane, K.P.B. (2010) Revisiting the Productivity and Efficiency of Ports and Terminals: Methods and Applications, in C. Grammenos [Ed.] Handbook of Maritime Economics and Business, Informa Publications, London, 907-946.

Clark, X., Dollar, D. and Micco, A. (2000). Maritime transport costs and port efficiency. Mimeo, World Wank, February.

ECA (2012). Special Report, Nº4. Using structural and cohesion funds to co-finance transport infrastructures in seaports: an effective investment? Pursuant to Article 287(4), second subparagraph, TFEU.

García-Alonso , L. and Martín-Bofarrul, M. (2007) Impact of Port investment on efficiency and capacity. Maritime Economics & Logistics, 9, pp. 254-267.

Gese Aperte, X. and Baird, A. (2012) Motorways of the sea policy in Europe. Journal of Maritime Policy & Management: The flagship journal of international shipping and portresearch.

Innes, R. (1990). “Limited Liabilities and Incentive Contracting with ex ante Action Choices.” Journal of Economic Theory 52: 45–67.

Laffont and Martimort, (2002) The theory of incentives, the principal-agent model. Princeton University Press.

Limao, A. and Venables, J. (2001) Infrastructure, geographical disadvantage and transport costs. World Bank Economic Review 15. Washington.

Compes Lopez, R. and Poole, N. (1998) Quality assurance in the maritime port logistics chain: the case of Valencia, Spain. Supply chain management: An international Journal, 3 (1), pp.33-44.

Luberoff, D., & Walder, J. (2000) U.S. Ports and the Funding of Intermodal Facilities: An Overview of Key Issues. Kennedy School of Government. Harvard University. Unpublished manuscript.

Maksimavičius, R. (2004) Some elements of the Ro-Ro terminals. Transport, 19:2, 75-81.

Medda, F. and Trujillo, L. (2009) A Boost for Short Sea Shipping: The Environmental and Economic Determinants. The Environmentalist 80, pp.14-20.

Milgrom, P. (1981) Good News and Bad News: Representation Theorems and Application. Bell Journal of Economics 12: 380–391.

Paixao Casaca, A.C. (2008) Motorways of the sea requirements> the viewpoint of port authorities. International Journal of Logistics Research and Applications. Vol.11, Issue 4.

Paixao, A.C. and Marlow, P.B. (2007) The Impact of the Trans-European Transport Networks on the Development of Short Sea Shipping. Maritime Economics & Logistics, vol. 9, pp 302–323.

Park, E. S. (1995) “Incentive Contracting with Limited Liability.” Journal of Economics and Management Strategy 4: 477–490.

Pettersen, S. (2004) Port pricing structures and ship efficiency. Review of Network Economics Vol.3, Issue 2 – June.

Sánchez, R., Hoffmann, J., Micco, A., Pizzolitto, G., Sgut, M, and Wilmsmeier, G., (2003) Port efficiency and international trade: Port efficiency as a determinant of maritime transport costs. Maritime economics and logistics, 5, pp. 199-218.

Suárez-Alemán, A., Trujillo, L. and Medda, F. (2012) Short Sea Shipping and intermodal competition. A theoretical analysis of European Transport Policies. IAME 2012 Proceedings. Taipei, Taiwan.

Wilmsmeier, G., Hoffmann, J. and Sanchez, R., (2006) The Impact of Port Characteristics on International Maritime Transport Costs. Research in Transportation Economics, vol. 16(1), pp. 117-140.

A.1. Annex I

Considering that the government has to minimize the social cost (S.C.), satisfying two conditions; the participation constraint (P. C.) and the restriction of incentives compatibility (R.I.C.), the problem is as follows:

$$Min\ SC$$

$$\sum_{i=1}^{N} p(e)[(m-c)\left[\frac{\varepsilon^R-\varepsilon^P}{t^P-t^R+\eta(e)}\right]-k-e+S\left[\eta(e)\right]\geq 0 \tag{10}$$

$$\frac{\partial}{\partial e}\left[\sum_{i=1}^{N} p(e)[(m-c)\left[\frac{\varepsilon^R-\varepsilon^P}{t^P-t^R+\eta(e)}\right]-k-e+S\left[\eta(e)\right]\right]\geq 0$$

To solve it, we compute the Lagrangian function,

$$\begin{aligned} L\left(e,\eta,\lambda,\mu\right) &= SC+\lambda\left[\sum_{i=1}^{N} p(e)[(m-c)\left[\frac{\varepsilon^R-\varepsilon^P}{t^P-t^R+\eta(e)}\right]-k-e+S\left[\eta(e)\right]\right] \\ &+\mu\left[\frac{\partial}{\partial e}\left[\sum_{i=1}^{N} p(e)[(m-c)\left[\frac{\varepsilon^R-\varepsilon^P}{t^P-t^R+\eta(e)}\right]-k-e+S\left[\eta(e)\right]\right]\geq 0\right] \end{aligned} \tag{11}$$

taking into account $SC=2m+t^R+2\varepsilon^R+S\left[\eta\left(e\right)\right]$, the first order condition with respect to η for a given level of effort is

$$\begin{aligned} \frac{\partial L\left(e,\lambda,\mu\right)}{\partial} &= p\left(e\right)S'(\eta)+\lambda p\left(e\right)S'(\eta)+ \\ &+\mu\left(p'(e)S'(\eta)+p\left(e\right)\left(\eta'(e)S''(\eta)-\frac{\left(c-m\right)\left(\varepsilon^P-\varepsilon^R\right)\eta''(e)}{(t^P-t^R+\eta(e))^2}\right)+S'(\eta)\eta''(e)\right), \end{aligned} \tag{12}$$

rearranging terms, and solving that problem for e, we have the equilibrium condition.

$$1=-\lambda-\mu\left(\frac{p'(e)}{p(e)}+\eta''(e)+\eta'(e)\frac{S''(\eta)}{S'(\eta)}-\frac{\left(c-m\right)\left(\varepsilon^P-\varepsilon^R\right)\eta''(e)}{S'(\eta)(t^P-t^R+\eta(e))^2}\right). \tag{13}$$